TABLE 17:

ADDITIONAL RISK PER ONE HUNDRED THOUSAND PERSONS FROM LIFETIME CONTINUOUS EXPOSURE TO 0.0005 TEM f/cc LONGER THAN 5.0 µm AND THINNER THAN 0.5 µm

Receptor Category	**Percent of Fibers Greater Than 10 µm in Length**										
	0	**0.05**	**0.10**	**0.50**	**1.00**	**2.00**	**5.00**	**10.00**	**20.00**	**50.00**	**100.00**
					CHRYSOTILE						
ALE NON-SMOKERS											
Lung Cancer	0.011	0.013	0.015	0.030	0.05	0.09	0.20	0.39	0.77	1.91	3.81
Mesothelioma	0.004	0.005	0.005	0.011	0.02	0.03	0.07	0.14	0.27	0.67	1.33
Combined	0.015	0.018	0.021	0.041	0.07	0.12	0.27	0.53	1.04	2.58	5.14
ALE NON-SMOKERS											
Lung Cancer	0.008	0.010	0.011	0.022	0.04	0.06	0.14	0.28	0.55	1.37	2.74
Mesothelioma	0.004	0.005	0.006	0.012	0.02	0.03	0.08	0.15	0.30	0.74	1.48
Combined	0.013	0.015	0.017	0.034	0.05	0.10	0.22	0.43	0.85	2.11	4.22
MALE SMOKERS											
Lung Cancer	0.097	0.112	0.128	0.256	0.42	0.74	1.70	3.29	6.49	16.08	32.06
Mesothelioma	0.003	0.003	0.004	0.007	0.01	0.02	0.05	0.09	0.18	0.45	0.90
Combined	0.099	0.116	0.132	0.264	0.43	0.76	1.74	3.39	6.67	16.53	32.96
FEMALE SMOKERS											
Lung Cancer	0.067	0.078	0.089	0.178	0.29	0.51	1.18	2.29	4.51	11.18	22.29
Mesothelioma	0.004	0.005	0.005	0.011	0.02	0.03	0.07	0.14	0.27	0.66	1.32
Combined	0.071	0.083	0.095	0.189	0.31	0.54	1.25	2.42	4.78	11.84	23.61
					AMPHIBOLE						
ALE NON-SMOKERS											
Lung Cancer	0.04	0.05	0.05	0.11	0.17	0.31	0.71	1.37	2.70	6.68	13.26
Mesothelioma	2.01	2.34	2.67	5.33	8.65	15.30	35.24	68.45	134.83	333.61	663.65
Combined	2.047	2.386	2.725	5.437	8.83	15.61	35.94	69.82	137.53	340.28	676.91
ALE NON-SMOKERS											
Lung Cancer	0.03	0.03	0.04	0.08	0.13	0.22	0.52	1.00	1.98	4.89	9.71
Mesothelioma	2.23	2.60	2.97	5.92	9.61	16.99	39.12	75.99	149.68	370.33	736.66
Combined	2.257	2.631	3.005	5.995	9.73	17.21	39.64	77.00	151.66	375.22	746.37
MALE SMOKERS											
Lung Cancer	0.38	0.45	0.51	1.02	1.66	2.93	6.75	13.12	25.84	63.91	127.06
Mesothelioma	1.36	1.58	1.81	3.61	5.86	10.35	23.84	46.32	91.23	225.72	449.00
Combined	1.742	2.031	2.319	4.628	7.51	13.29	30.60	59.44	117.08	289.63	576.06
FEMALE SMOKERS											
Lung Cancer	0.27	0.32	0.36	0.72	1.17	2.07	4.76	9.25	18.23	45.10	89.70
Mesothelioma	1.98	2.31	2.64	5.27	8.55	15.12	34.83	67.66	133.27	329.68	655.65
Combined	2.255	2.628	3.002	5.989	9.72	17.19	39.59	76.92	151.50	374.78	745.35
								Source:	Berman and Crump 2001		

TABLE 18:								
RECOMMENDED UNIT RISK FACTORS (URF'S) FOR ASBESTOS								
Units for URF's are: $(s/cm^3)^{-1}$								
URF for current U.S.EPA approach: (IRIS 1988):								
	Asbestos 7402 Structures			0.23				
URF's for new, proposed approach (Berman and Crump 2001):								
	Percent Longer than 10 um			1%	10%	30%	50%	100%
	Chrysotile Protocol Structures			0.0025	0.020	0.059	0.098	0.19
	Amphibole Protocol Structures			0.18	1.4	4.2	7.0	14
Notes:								
	The URF for the current approach must be matched with exposrue estimates derived from measurements of 7402 (PCM Equivalent) only.							
	The URF's for the new, proposed approach must be matched with exposure estimates derived from measurements of protocol structures only.							
	Because URF's employed in each of the two approaches must be paired with different size fractions of structures, URF values *cannot* be directly compared.							
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TABLE 19:

AIRBORNE EXPOSURE POINT CONCENTRATIONS FOR CHRYSOTILE MODELED FROM BULK MEASUREMENTS AND THE ASSOCIATED RISK AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

			Estimated Asbestos Concentrations					
		Time Averaged	in Source Material[a]		at Exposure Points[b]			
		Dust	Protocol	7402	Protocol	7402	Estimated Risk	
		Concentration	Structures[c]	Structures	Structures	Structures	Protocol	7402
Activity		(mg/m^3)	(s/g$_{PM10}$)	(s/g$_{PM10}$)	(s/cm^3)	(s/cm^3)	Structures	Structures
Residential Pathways								
	Walking	2.7E-02	1.9E+07 [d]	7.2E+06 [d]	5.1E-04	1.9E-04	5.E-05	4.E-05
	Running	5.0E-02	1.9E+07 [d]	7.2E+06 [d]	9.5E-04	3.6E-04	9.E-05	8.E-05
	Bicycling	4.0E-02	1.9E+07 [d]	7.2E+06 [d]	7.6E-04	2.9E-04	7.E-05	7.E-05
	Gardening	7.3E-04	3.0E+08 [e]	1.3E+08 [e]	2.2E-04	9.5E-05	2.E-05	2.E-05
	Playing in Soil	9.9E-04	3.0E+08 [e]	1.3E+08 [e]	3.0E-04	1.3E-04	3.E-05	3.E-05
	Combined Gardening and Play	1.3E-03	3.0E+08 [e]	1.3E+08 [e]	4.0E-04	1.7E-04	4.E-05	4.E-05
	Playing w ACM	3.5E-04	6.3E+09 [f]	2.2E+09 [f]	2.2E-03	7.6E-04	**2.E-04**	**2.E-04**
	Rototilling	2.6E-02	1.9E+07 [d]	7.2E+06 [e]	4.9E-04	1.9E-04	5.E-05	4.E-05
	ATV	8.3E-02	1.9E+07 [d]	7.2E+06 [d]	1.6E-03	6.0E-04	**2.E-04**	**1.E-04**
Worker Pathways								
	Bulldozer Excavation	1.0E+00	1.9E+07 [d]	7.2E+06 [d]	2.0E-02	7.4E-03	**2.E-03**	**2.E-03**
	Loading/Dumping	4.0E-04	1.9E+07 [d]	7.2E+06 [d]	7.7E-06	2.9E-06	8.E-07	7.E-07
	Grading	1.1E-01	1.9E+07 [d]	7.2E+06 [d]	2.1E-03	7.8E-04	**2.E-04**	**2.E-04**
	Transport (SSL)	2.1E-03	1.9E+07 [d]	7.2E+06 [d]	3.9E-05	1.5E-05	4.E-06	3.E-06
	Full Dust Control	1.6E-02	1.9E+07 [d]	7.2E+06 [d]	3.1E-04	1.2E-04	3.E-05	3.E-05
Worker Pathways (Remediation Scenario)								
	Bulldozer Excavation	1.7E-01	3.0E+08 [e]	1.3E+08 [e]	5.2E-02	2.2E-02	**5.E-03**	**5.E-03**
	Loading/Dumping	6.7E-05	3.0E+08 [e]	1.3E+08 [e]	2.0E-05	8.8E-06	2.E-06	2.E-06
	Grading	1.8E-02	3.0E+08 [e]	1.3E+08 [e]	5.4E-03	2.4E-03	**5.E-04**	**5.E-04**
	Transport (SSL)	3.4E-04	3.0E+08 [e]	1.3E+08 [e]	1.0E-04	4.4E-05	1.E-05	1.E-05
	Full Dust Control	2.7E-03	3.0E+08 [e]	1.3E+08 [e]	8.2E-04	3.5E-04	8.E-05	8.E-05
Offsite Impact to Residents								
	Combined construction	2.1E-03	1.9E+07 [d]	7.2E+06 [d]	3.9E-05	1.5E-05	4.E-06	3.E-06
	Construction w Dust Control	2.1E-03	1.9E+07 [d]	7.2E+06 [d]	3.9E-05	1.5E-05	4.E-06	3.E-06
	Remediation Scenario	3.4E-04	3.0E+08 [e]	1.3E+08 [e]	1.0E-04	4.4E-05	1.E-05	1.E-05
	Remediation w Dust Control	3.4E-04	3.0E+08 [e]	1.3E+08 [e]	1.0E-04	4.4E-05	1.E-05	1.E-05

Notes:

[a] These are chrysotile concentrations in bulk phase materials (soils).

[b] These are corresponding estimates of airborne chrysotile concentrations at receptor locations.

[c] These represent total protocol structures with 50% longer than 10 µm (based on data presented in Table 16).

[d] Assumes the maximum observed concentration among composite soil samples with contributions from ACM included (Table 16).

[e] Assumes the maximum observed concentration of asbestos in soils (in this case, a hot spot) including contributions from embedded ACM (Table 16).

[f] Assumes the maximum observed concentration of asbestos in ACM (Table 16).

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TABLE 20:

AIRBORNE EXPOSURE POINT CONCENTRATIONS FOR AMPHIBOLE ASBESTOS MODELED FROM BULK MEASUREMENTS AND THE ASSOCIATED RISK AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

Activity	Time Averaged Dust Concentration (mg/m^3)	Estimated Asbestos Concentrations in Source Material[a]: Protocol Structures[c] (s/g_{PM10})	Estimated Asbestos Concentrations in Source Material[a]: 7402 Structures (s/g_{PM10})	Estimated Asbestos Concentrations at Exposure Points[b]: Protocol Structures (s/cm^3)	Estimated Asbestos Concentrations at Exposure Points[b]: 7402 Structures (s/cm^3)	Estimated Risk: Protocol Structures	Estimated Risk: 7402 Structures
Residential Pathways							
Walking	2.7E-02	2.0E+05 [d]	2.0E+05 [d]	5.3E-06	5.3E-06	4.E-05	1.E-06
Running	5.0E-02	2.0E+05 [d]	2.0E+05 [d]	1.0E-05	1.0E-05	7.E-05	2.E-06
Bicycling	4.0E-02	2.0E+05 [d]	2.0E+05 [d]	8.0E-06	8.0E-06	6.E-05	2.E-06
Gardening	7.3E-04	8.0E+06 [e]	2.0E+07 [e]	5.8E-06	1.5E-05	4.E-05	3.E-06
Playing in Soil	9.9E-04	8.0E+06 [e]	2.0E+07 [e]	7.9E-06	2.0E-05	6.E-05	5.E-06
Combined Gardening and Play	1.3E-03	8.0E+06 [e]	2.0E+07 [e]	1.1E-05	2.7E-05	7.E-05	6.E-06
Playing w ACM	3.5E-04	2.4E+10 [f]	1.4E+10 [f]	8.3E-03	4.8E-03	**6.E-02**	**1.E-03**
Rototilling	2.6E-02	2.0E+05 [d]	2.0E+05 [d]	5.2E-06	5.2E-06	4.E-05	1.E-06
ATV	8.3E-02	2.0E+05 [d]	2.0E+05 [d]	1.7E-05	1.7E-05	**1.E-04**	4.E-06
Worker Pathways							
Bulldozer Excavation	1.0E+00	2.0E+05 [d]	2.0E+05 [d]	2.1E-04	2.1E-04	**1.E-03**	5.E-05
Loading/Dumping	4.0E-04	2.0E+05 [d]	2.0E+05 [d]	8.1E-08	8.1E-08	6.E-07	2.E-08
Grading	1.1E-01	2.0E+05 [d]	2.0E+05 [d]	2.2E-05	2.2E-05	**2.E-04**	5.E-06
Transport (SSL)	2.1E-03	2.0E+05 [d]	2.0E+05 [d]	4.1E-07	4.1E-07	3.E-06	9.E-08
Full Dust Control	1.6E-02	2.0E+05 [d]	2.0E+05 [d]	3.3E-06	3.3E-06	2.E-05	8.E-07
Worker Pathways (Remediation Scenario)							
Bulldozer Excavation	1.7E-01	8.0E+06 [e]	2.0E+07 [e]	1.4E-03	3.4E-03	**1.E-02**	**8.E-04**
Loading/Dumping	6.7E-05	8.0E+06 [e]	2.0E+07 [e]	5.4E-07	1.3E-06	4.E-06	3.E-07
Grading	1.8E-02	8.0E+06 [e]	2.0E+07 [e]	1.4E-04	3.6E-04	**1.E-03**	8.E-05
Transport (SSL)	3.4E-04	8.0E+06 [e]	2.0E+07 [e]	2.7E-06	6.8E-06	2.E-05	2.E-06
Full Dust Control	2.7E-03	8.0E+06 [e]	2.0E+07 [e]	2.2E-05	5.4E-05	**2.E-04**	1.E-05
Offsite Impact to Residents							
Combined construction	2.1E-03	2.0E+05 [d]	2.0E+05 [d]	4.1E-07	4.1E-07	3.E-06	9.E-08
Construction w Dust Control	2.1E-03	2.0E+05 [d]	2.0E+05 [d]	4.1E-07	4.1E-07	3.E-06	9.E-08
Remediation Scenario	3.4E-04	8.0E+06 [e]	2.0E+07 [e]	2.7E-06	6.8E-06	2.E-05	2.E-06
Remediation w Dust Control	3.4E-04	8.0E+06 [e]	2.0E+07 [e]	2.7E-06	6.8E-06	2.E-05	2.E-06

Notes:

[a] These are amosite (amphibole asbestos) concentrations in bulk phase materials (soils).

[b] These are corresponding estimates of airborne amosite concentrations at receptor locations.

[c] These represent total protocol structures with 50% longer than 10 µm (based on data presented in Table F-2).

[d] Assumes the estimate of amphibole asbestos concentrations derived as the UCL for samples in which no protocol structures or 7402 structures are actually detected (Table F-2).

[e] Assumes the maximum observed concentration of amosite in soils (in this case, a hot spot) including contributions from embedded ACM (Table F-2).

[f] Assumes the maximum observed concentration of amosite in ACM (Table 16).

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TABLE 21:
ESTIMATED OCCURRENCE OF AMPHIBOLE AND RELATIVE CONTRIBUTIONS TO RISK FROM EXPOSURE TO CHRYSOTILE, AMPHIBOLE ASBESTOS, AND THE TWO COMBINED AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

	Estimated Risk				Combined Estimated Risk	
	From Chrysotile		From Amphibole			
	Protocol	7402	Protocol	7402	Protocol	7402
Activity	Structures[c]	Structures	Structures	Structures	Structures	Structures
Residential Pathways						
Walking	5.E-05	4.E-05	4.E-05	1.E-06	9.E-05	5.E-05
Running	9.E-05	8.E-05	7.E-05	2.E-06	**2.E-04**	8.E-05
Bicycling	7.E-05	7.E-05	6.E-05	2.E-06	**1.E-04**	7.E-05
Gardening	2.E-05	2.E-05	4.E-05	3.E-06	6.E-05	3.E-05
Playing in Soil	3.E-05	3.E-05	6.E-05	5.E-06	8.E-05	3.E-05
Combined Gardening and Play	4.E-05	4.E-05	7.E-05	6.E-06	**1.E-04**	5.E-05
Playing w ACM	**2.E-04**	**2.E-04**	**6.E-02**	**1.E-03**	Not Applicable	
Rototilling	5.E-05	4.E-05	4.E-05	1.E-06	8.E-05	4.E-05
ATV	**2.E-04**	**1.E-04**	**1.E-04**	4.E-06	**3.E-04**	**1.E-04**
Worker Pathways						
Bulldozer Excavation	**2.E-03**	**2.E-03**	**1.E-03**	5.E-05	**3.E-03**	**2.E-03**
Loading/Dumping	8.E-07	7.E-07	6.E-07	2.E-08	1.E-06	7.E-07
Grading	**2.E-04**	**2.E-04**	**2.E-04**	5.E-06	**4.E-04**	**2.E-04**
Transport (SSL)	4.E-06	3.E-06	3.E-06	9.E-08	7.E-06	3.E-06
Full Dust Control	3.E-05	3.E-05	2.E-05	8.E-07	5.E-05	3.E-05
Worker Pathways (Remediation Scenario)						
Bulldozer Excavation	**5.E-03**	**5.E-03**	**1.E-02**	**8.E-04**	**1.E-02**	**6.E-03**
Loading/Dumping	2.E-06	2.E-06	4.E-06	3.E-07	6.E-06	2.E-06
Grading	**5.E-04**	**5.E-04**	**1.E-03**	8.E-05	**2.E-03**	**6.E-04**
Transport (SSL)	1.E-05	1.E-05	2.E-05	2.E-06	3.E-05	1.E-05
Full Dust Control	8.E-05	8.E-05	**2.E-04**	1.E-05	**2.E-04**	9.E-05
Offsite Impact to Residents						
Combined construction	4.E-06	3.E-06	2.E-05	2.E-06	7.E-06	3.E-06
Construction w Dust Control	4.E-06	3.E-06	2.E-05	2.E-06	7.E-06	3.E-06
Remediation Scenario	1.E-05	1.E-05	3.E-06	3.E-07	3.E-05	1.E-05
Remediation w Dust Control	1.E-05	1.E-05	3.E-06	3.E-07	3.E-05	1.E-05

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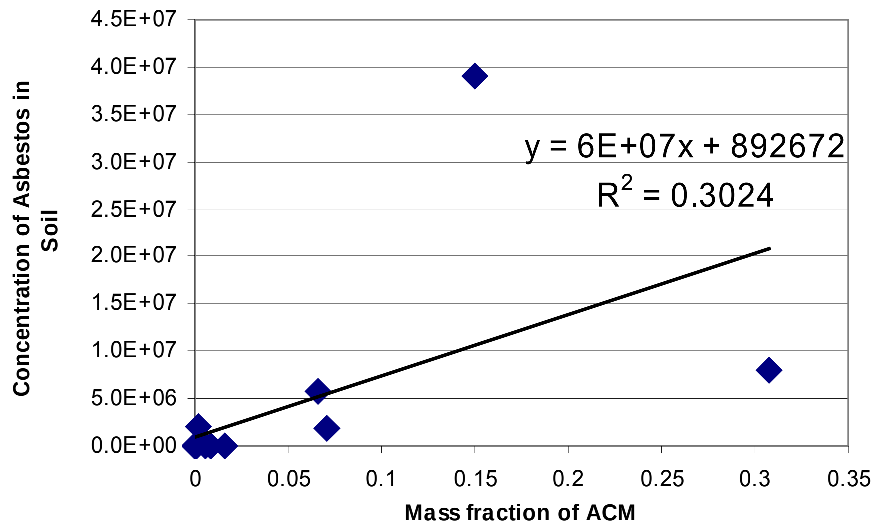
TABLE 22:
CHARACTERIZATION AND MANAGEMENT OF SOURCES OF UNCERTAINTY/VARIABILITY IN THIS STUDY OF ASBESTOS EXPOSURE AND RISK AT THE NORTH RIDGE ESTATES SITE

Source of Uncertainty/Variability		Nature	Estimated Magnitude	How Addressed
Contributions from Sampling and Analysis:				
	Spatial variability in asbestos concentrations in soil/ACM	Variability	Large	Controlled by categorizing measured concentrations into groups representative of sources and choosing conservative estimates of concentration for each source type
	Random error in collection of samples representative of defined locations	Uncertainty	Small	Controlled by collecting large volume samples per strict procedures
	Random error in preparation of samples	Uncertainty	Small	Characterized to assure acceptability
	Random analytical error in measurement	Uncertainty	Small	Characterized to assure acceptability
	Spatial variability in silt content	Variability	Small to Moderate	Controlled by selecting value near upper end of the range of measured values
Contributions from Modeling Exposure:				
	Quality of match between model and exposure pathway modeled	Uncertainty	Moderate[a]	Controlled by using properly matched, existing models to the extent possible and employing simple adaptations when required that, if anything, appear biased to be conservative
	Overall precision of model	Uncertainty	Moderate[a]	Controlled by using conservative estimates of values for input parameters
	Representativeness of input values used in modeling for actual conditions at site	Uncertainty	Small to Moderate[a]	Controlled by using conservative, literature default values and/or conservative, bounding estimates of measured or location-specific values
	Representativeness of duration and frequency estimates to actual behavior of site residents	Variability	Moderate	Controlled by using conservative, literature default values when available[a,b]
Contributions from Risk Modeling:				
	Uncertainty in exposure-response factors derived from epidemiological literature	Uncertainty	Moderate	Controlled by using conservative, upper bound estimates of slope factors for both protocols applied to assess risk
	Representativeness of exposure-response models applied to epidemiological data to derive exposure-response factors	Uncertainty	Moderate	Controlled by using conservative, upper bound estimates of slope factors for both protocols applied to assess risk and formally fit-testing the models[c]
	Representativeness of exposure-response factors to specific character of exposure at site	Uncertainty	Moderate	Controlled by using two separate, independent protocols that are each leading candidates for assessing risk and by using conservative, upper bound estimates of slope factors for both protocols that were applied to assess risk
Notes:				
[a]	The one exception to the characterization of the magnitude of uncertainty associated with modeling exposure indicated in the table is the model for handling and abrading ACM. This model is highly uncertain and appropriate values for two of the input parameters are based on educated guesstimates.			
[b]	While the duration and frequency estimates for rototilling and ATV riding appear reasonable, due to lack of literature values, the degree of uncertainty of such estimates is not known.			
[c]	The same, EPA-developed exposure models for lung cancer and mesothelioma are employed to evaluate epidemiological data in both protocols. The two protocols differ primarily in (1) the index employed for characterizing exposure, (2) values for the recommended exposure-response factors, and (3) the set of literature studies included in the analyses. The Berman and Crump (2001) protocol considers newer studies and a larger number of studies than were available when the current EPA protocol (IRIS 1988) was developed.			
				D. Wayne Berman, Aeolus, Inc.

FIGURES

FIGURE 1:
CORRELATION BETWEEN ASBESTOS CONCENTRATIONS AND THE MASS FRACTION OF ACM IN SOIL



APPENDIX A:
LOCATIONS AND DESCRIPTIONS OF SOIL SAMPLES COLLECTED FROM THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

As previously indicated, two sets of soil samples were collected. The first set is comprised of composite samples collected to represent general field conditions in the area. Each composite was generated by combining 12 component samples collected at locations identified using a stratified-random sampling scheme within the area represented by the particular composite (Berman 2003). The portions of the site represented by each of the 10 composites that were analyzed are depicted on the map in Figure A-1. The locations from which the individual component samples were collected are also presented.

The second set is comprised of samples collected from "hot spots" (areas identified by the U.S.EPA's On-scene coordinator that contain high concentrations and/or particularly weathered ACM. These seven hot spot samples were collected from the locations depicted in Figure A-2. A physical description of each hot spot area sampled follows.

Hot Spot 1

This hot spot was collected from the front yard of a residence near the northwest corner of the site. The ACM observed to be buried at this location was a combination of black roofing material and off-white dimpled wall board.

Hot Spot 2

This hot spot was also collected from the front yard of a (different) residence in the northwest portion of the site. The ACM observed at this location consisted of black laminar roofing material and a large amount of very fine roofing material that could not be efficiently separated from the soil sample collected in the area.

Hot Spot 3

This hot spot was located in the backyard of a residence in the northwest portion of the site. The ACM at this location consisted of off-white, dimpled wall board.

Hot Spot 4

Hot Spot 4 was located in the backyard of a residence in the north-central portion of the site. The ACM consisted of a combination of black roofing material and off-white dimpled wall board.

Hot Spot 5

Hot Spot 5 was located behind the garage of a residence located in the central southern area of the site. The ACM at this location also consisted of a combination of black roofing material and off-white dimpled wall board.

Hot Spot 6

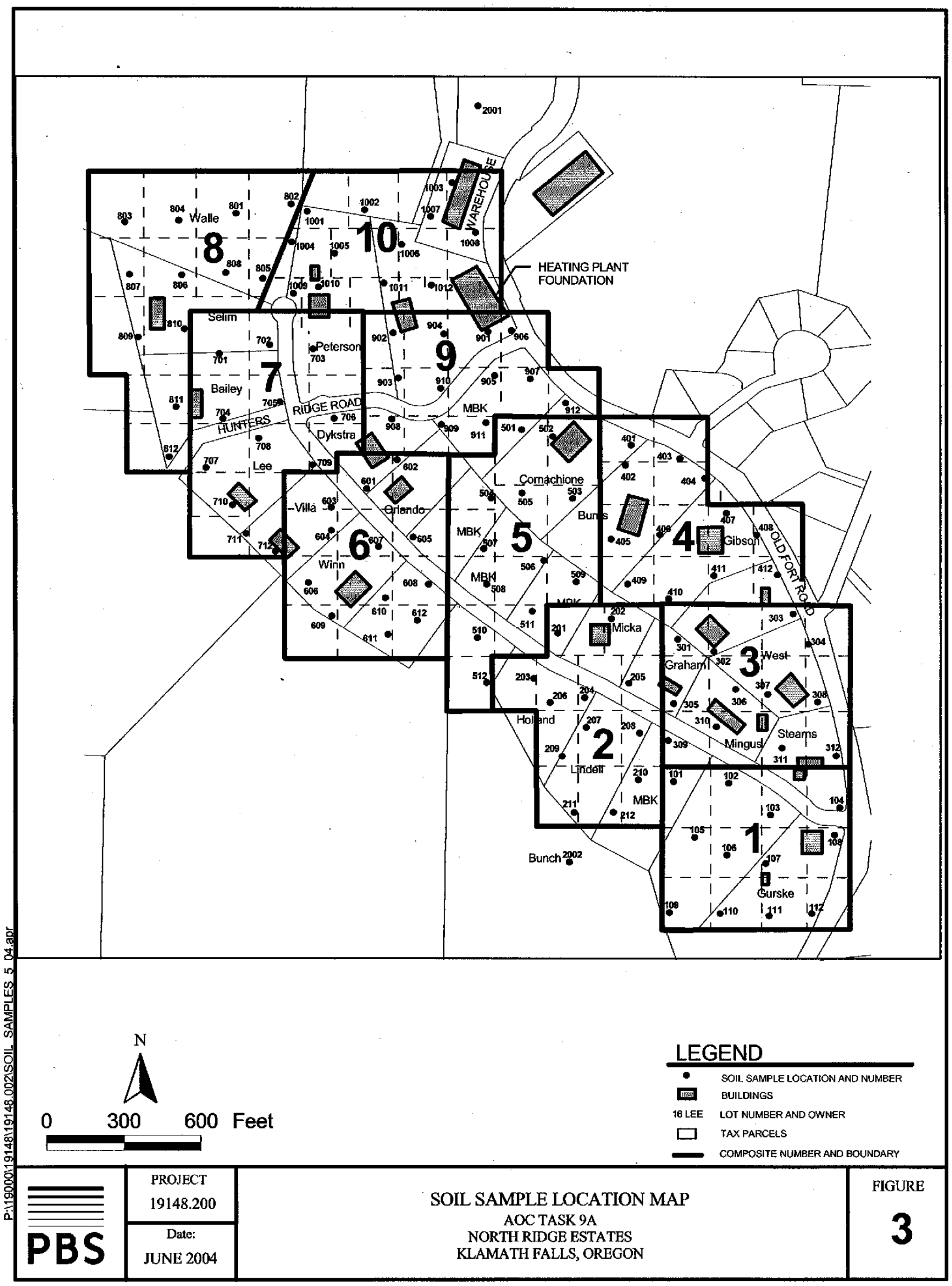
The sample for this hot spot was collected from a hole in a cratered area on the south side of a large foundation located in the north-central part of the site. The material collected as ACM in this area was noted to be wall board-like, beige colored with a denim texture, but not dimpled. It was noted by field personnel to resemble a clayey or plaster-type material. Field personnel also noted the lack of visible fibers, which they suggested cast doubt on the material's pedigree as ACM.

According to the field sampling team (Colin Polk, PBS, private communication), the foundation from which this sample was collected lies approximately 6 inches below grade and the depth from which the sample was collected lies an additional 0 to 6 inches below the foundation. Thus, this sample was collected between a depth of 6 and 12 inches below grade.

Hot Spot 7

This hot spot was located on a sloped-grassy area on the southeast portion of the site. The ACM at this location was noted to be highly-weathered wall board. It was also noted that, due to the weathering, it was virtually impossible to efficiently separate the ACM from the soil component of the sample from this hot spot.

FIGURE A-1:
SAMPLING LOCATIONS FOR COMPONENT SAMPLES AND COMPOSITE GROUPINGS
NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON



Notes:

- Small squares represent boxes within which component samples were collected with the specific location selected at random.
- The irregularly shaped areas indicated by the heavier outlines represent the areas represented by each correspondingly numbered composite. Note that there are 12 small squares per area.

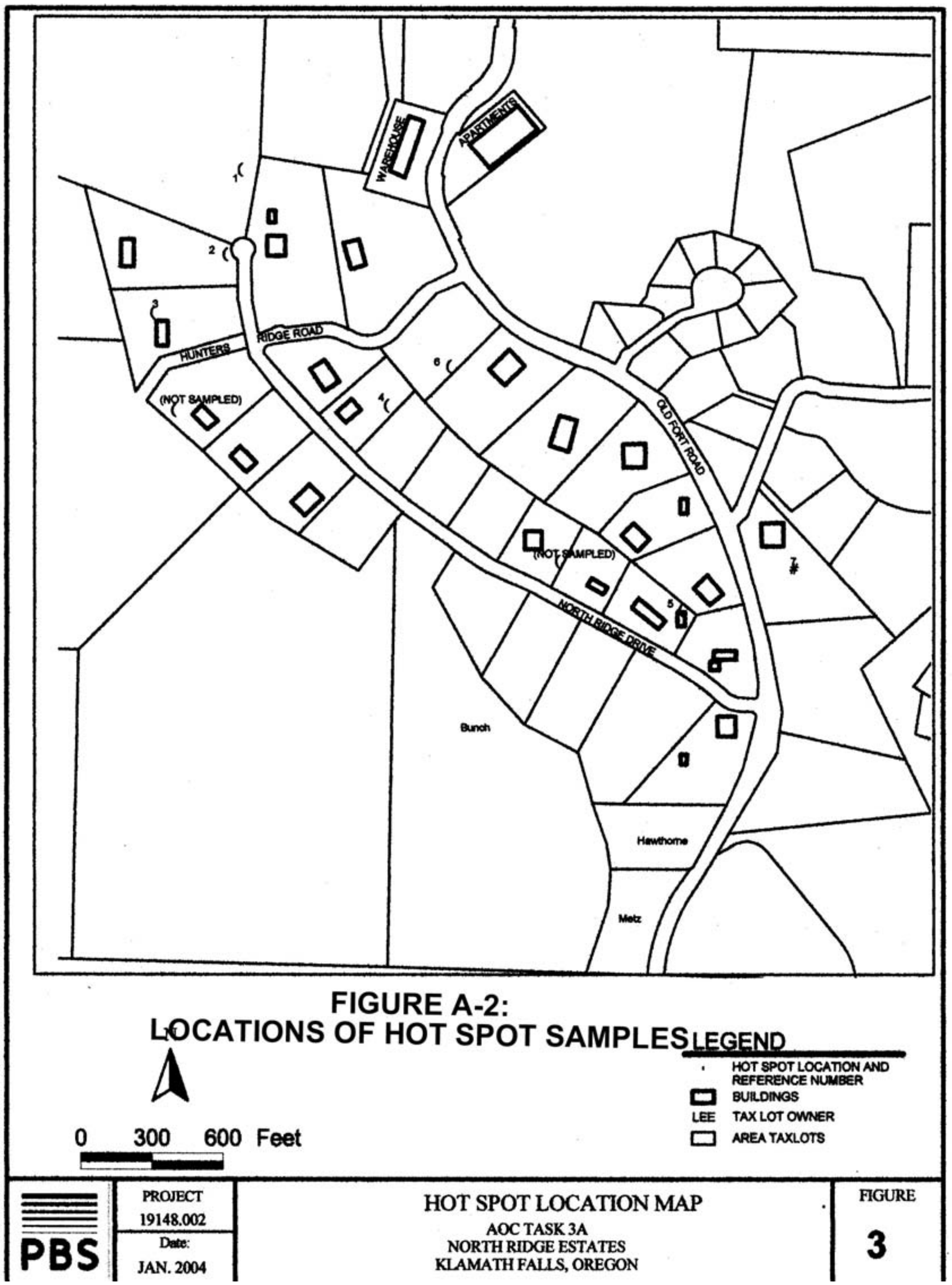


FIGURE A-2:
LOCATIONS OF HOT SPOT SAMPLES

APPENDIX B:
RESULTS OF ANALYSES OF SOIL SAMPLES COLLECTED FROM THE NORTH RIDGE ESTATES SITE THAT WERE SUBJECTED TO A FULL ISO COUNT

Table B-1 presents results from analyses of the four soil samples selected for full ISO characterization. In Table B-1, the first column indicates the nature of the characteristic of each sample presented. The next four columns indicate the value for each characteristic associated with each sample listed at the head of the column. The last column indicates the units for the numerical values presented for specific characteristics.

In addition to indicating the sample type (i.e. soil or ACM) and the specific location from which each sample was collected, Table B-1 indicates the number of various types of asbestos structures (total protocol, long protocol, 7402, or other ISO structures) observed in each sample. The analytical sensitivity for the count of each respective type of structure is also provided along with estimates of the concentration of each type of structure observed in the table.

Note that all of the “other” ISO structures observed in these samples were short structures (i.e. shorter than 5 μm). The last column in the table indicates the ratio of short ISO structures to long ISO structures observed in each sample.

As can be seen from the last row of the table short structures represent between approximately 67% [=2.0/(2.0+1)] and 82% [=4.7/(4.7+1)] of the structures observed in each sample. This is consistent with general observations from the literature (see, for example, Berman and Chatfield 1990) that size distributions for asbestos structures tend to be dominated by short structures, which commonly represent between 60 and 95% of a distribution.

As previously indicated, although there is currently no formal procedure for independently assessing the hazard associated with exposure to short asbestos structures, the best estimate is that such hazards are small relative to exposure to longer structures (see, for example, Berman and Crump 2001). Moreover, any contribution to risk from short structures is entirely addressed by default when evaluating the risk to longer structures because short structures were present in all of the environments in which the available epidemiology studies were conducted. For a more detailed discussion, see Berman and Crump (2001).

TABLE B-1
RESULTS OF ANALYSES OF SAMPLES FROM NORTH RIDGE ESTATES SUBJECTED TO A FULL ISO COUNT

Characteristics	Sample Number				Units
	29	76	81	101	
Sample Type	soil	soil	soil	ACM	
Sample Location	C8	HS-6	HS-7	HS-7	
Number of Structures					
Total Protocol	0	20	35	75	Number
Long Protocol	0	8	13	30	Number
7402	0	44	4	19	Number
Total Long	0	58	36	86	Number
Other ISO	0	33	24	404	Number
Analytical Sensitivity					
Total Protocol	2.0E+06	2.0E+06	2.3E+06	4.2E+07	str/g_{PM10}
Long Protocol	2.0E+06	2.0E+06	2.3E+06	4.2E+07	str/g_{PM10}
7402	2.0E+06	2.0E+06	2.3E+06	4.2E+07	str/g_{PM10}
Total Long	2.0E+06	2.0E+06	2.3E+06	4.2E+07	str/g_{PM10}
Other ISO	1.1E+07	9.7E+06	6.8E+06	4.2E+07	str/g_{PM10}
Concentration of Structures					
Total Protocol	0	4.0E+07	8.1E+07	3.2E+09	str/g_{PM10}
Long Protocol	0	1.6E+07	3.0E+07	1.3E+09	str/g_{PM10}
7402	0	8.8E+07	9.2E+06	8.0E+08	str/g_{PM10}
Total Long	0	1.2E+08	8.3E+07	3.6E+09	str/g_{PM10}
Other ISO	0	3.2E+08	1.6E+08	1.7E+10	str/g_{PM10}
Ratio of Total Short to Long	ND	2.7	2.0	4.7	Unitless

APPENDIX C:
EVALUATION OF THE RELATIVE AREA OF CONTACT FOR VEHICLE TIRES AND FEET BASED ON VEHICLE WEIGHT, INFLATION PRESSURE, AND FOOTSIZE.

A series of information sources were reviewed to facilitate an informal evaluation and comparison the relative tire pressures typically recommended among cars, trucks, and bicycles. Tire pressure data were obtained from:

1. The physics Factbook (Ehert, G. ed.): http://hypertextbook.com/facts/2003/SharaKhan.shtml (for bicycle tire pressures);

2. The physics Factbook (Ehert, G. ed.): http://hypertextbook.com/facts/2003/AlexandraKanonik.shtml (for truck tire pressures; and

3. http://www.drivegreen.com/pressureData.shtml (for automobile tire pressures).

A comparison of tire pressures among car tires indicates that (over a broad range of makes, models, and years) tire pressures are fairly similar and average between 30 and 35 psi (lbs per sq in). Recommended pressures for tires of light, medium, and heavy duty trucks run over a slightly broader range (about 30 to 40 psi) but are generally comparable. Thus, given that the footprint (the area of the tire in direct contact with the ground) of a tire is equal to the weight carried by that tire divided by the pressure to which it is inflated, it appears that footprint areas for tires can be assumed to differ primarily by the weight borne by the tire. In turn, this is a function of the total vehicle weight and the number of tires. Thus, the Copeland model appears to generally address the footprint area by default (along with other factors).

Bicycle tire pressures vary more radically. For high-performance and touring bicycles (those with the thin tires), typical tire pressures range between about 80 and 120 psi. For off-road bicycles and other bicycles with thicker tires, recommended tire pressures are range closer to 40 to 60 psi. Thus, it appears that some kind of adjustment for “footprint” area of each tire is warranted. Similarly, human feet, for which the area of contact is more a function of the structure of the foot than pressure per say, also appear to require some kind of adjustment for “footprint” area, if the Copeland model is to be adapted to foot transport.

Calculations performed to estimate the relative footprint areas appropriate for automobile transport, bicycle transport, and walking or running are summarized in Table C-1. Note, that, although scenarios for children and adults are both presented in the table (so that they can be compared), the adult scenarios are clearly the more conservative of the two in these cases. Therefore, only the adult scenarios are considered further in this report.

TABLE C-1:
DATA USED TO DETERMINE THE RELATIVE FOOTPRINT OF TIRES AND FEET

	Mean Wt. (lbs)	Typical Tire Pressue (lbs/in^2)	Number of wheels or feet	Source of Information
Adult	160		2	a
Chid	30		2	a
Bicycle	30		2	b
Adult +Bicycle	190		2	calculated
Child+Bicycle	60		2	calculated
Touring Bicycle		110	2	c
Off-road Bicycle		45	2	c
Automile	3000	30	4	c
Truck	20000	30	18	c

Pathway		Total Weight (lbs)	Wt.per wheel/foot (lbs)	Contact Area per wheelt/foot[d] (in^2)		Ratio Contact Area to Automobile[e]	Total Relative Contact Area[f]
Walking							
	Adult	160	80	30	[g]	1.2	2.4
	Child	30					
Tour Bicycling							
	Adult	190	95	0.86		0.03	0.07
	Child	60					
Off-road Bicycling							
	Adult	190	95	2.11		0.1	0.17
	Child	60					
Autmobile		3000	750	25		1.0	4.0
Truck		20000	1,111	37		1.5	26.7

Notes:

[a] U.S.EPA (1997)

[b] Estimated, based on personal experience

[c] From the sources listed in the text of this Appendix

[d] As indicated in the text, except for wlaking (or running) this is determined as the weight borne by the tire divided by the pressure in the tire.

[e] This is simply the ratio of the estimated footprint per tire (or foot) for the indicated pathway divided by the estimated footprint for an autormobile tire

[f] This is simply the ratio of the contact area to an automobile (per tire or foot) to multiplied by the total number of tires (or feet) appropriate for the stated pathway

[g] a human foot was assumed to be 12 in long by 2.5 in wide on average Note that this is conservative, considering how litle of a foot is actually in direct contact with the ground.

APPENDIX D:
SUMMARY OF SILT CONTENT MEASURMENTS COLLECTED
AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

Results of Silt content measurements from the North Ridge Estates Site are summarized in the following table:

Identifier for Sample Split Analyzed for Silt	Corresponding Soil Sample Number	Silt Content (Wt %)
4	1 (C1)	32.2
8	5 (C2)	34.1
12	9 (C3)	32.7
16	14 (C4)	21.4
20	19 (C5)	37.6
24	22 (C6)	33.5
28	25 (C7)	36.2
32	29 (C8)	36.7
36	34 (C9)	24.2
40	39 (C10)	31.6
44	45(Background S)	17.9
48	45 (Background N)	38.0
58	56 (HS 1)	24.1
62	59 (HS-2)	15.7
66	64 (HS-3)	31.1
70	69 (HS-4)	37.7
74	71 (HS-5)	32.6
78	76 (HS-6)	20.7
82	81 (HS-7)	27.7

APPENDIX E:
DEFINING AN APPROPRIATE WIDTH FOR BOX WITHIN WHICH DISPERSION OCCURS IN ASSOCIATION WITH DUST GENERATING ACTIVITIES AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

When using simple box models, it is important to size the box so that the resulting dilution is adequate to allow for reasonable judgment while assuring that the extent of dilution is highly likely to be conservative (in a health protective sense) relative to actual conditions in the field. Therefore, different considerations apply depending on whether a potentially exposed individual is the direct cause of the disturbance leading to exposure or whether such an individual is merely located in the immediate vicinity. Different considerations also apply depending on whether the disturbance is caused by motions of the foot, the hand, or a mechanical extension of either and whether the individual is crouching, sitting, or standing. It is also important to consider whether the source of the disturbance is moving or stationary.

Walking, Running, Bicycling, and Rototilling

For exposure pathways involving walking, running, bicycling, or rototilling, the situation is one in which releases occur essentially at ground level and the potentially exposed individual is standing. In all these cases, it is also important to consider that the source and the receptor are moving in tandem relative to the ground and the air.

When a receptor is located immediately over a source in an open space, unless they are standing in absolutely still air, even the slightest wind will tend to direct the plume of released dust away from the receptor and exposure will be minimal. This effect is even more pronounced when the source and receptor are moving (in tandem) because their motion relative to the air effectively creates the wind that will carry away the plume of dust. Therefore, for these exposure pathways, exposure to the individual participating directly in the disturbing activity will tend to experience little to no exposure most of the time.

Actually, while bicycling or rototilling, individuals may be slightly more likely to experience at least minor exposures than during walking or running because at least some of the mechanical activity causing dust generation is displaced some distance forward of the individual; the front tire of a bicycle and the rototiller are typically a couple of feet in front of the driver. Still, as suggested by the calculations presented in Table E-1, unless a bicycle or rototiller approaches a length of 3 m (10 ft), this effect should be minor.

In Table E-1, horizontal and vertical dispersion coefficients[1] for air (σ_y and σ_z, respectively) are extrapolated to small distances to provide a *rough* indication of the degree with which a ground level plume might spread to the height of a standing man (approximately 1.75 m). In the upper portion of the table, reported values for these two parameters are presented at each of four distances downwind (100, 200, 500, and 1,000 m) for each of two stability classes (which indicate the degree of turbulence in the air). The two classes selected, “A” and “C”, represent extremely unstable conditions and average conditions, respectively. Correspondingly, it can be seen that the values reported for the two dispersion coefficients (at any fixed distance downwind) are much larger under unstable condition “A” than under average condition “C”.

In the next section of Table E-1, the results of linear regression analyses conducted on each of the four columns of dispersion coefficient values are presented. As can be seen in this portion of the table, for all except σ_z (the vertical dispersion coefficient) under “A” stability conditions, an excellent fit to the data is obtained from a linear function with the slope indicated in the first row and the intercept indicated in the second row. The correlation coefficients for all of these relationships (except that for σ_z) are greater than 0.99.

[1] As indicated in the main body of the text, dispersion coefficients are indicators of the degree that a plume disperses in air as a function of distance downwind. They are parameters incorporated into the dispersion portion of the models used to evaluate exposure.

Among other things, the problem with the linear regression fit of σ_z yields a negative intercept, which is not physically possible; one cannot have negative dispersion at any distance from a source. An examination of the graph of σ_z (Figure 3.3 of Turner 1970) suggests why the linear regression does not fit this coefficient as well as the others. Substantial curvature is observed for distances greater than about 400 m. Thus, an alternate extrapolation was performed for this coefficient using only a couple of values (at 100 and 200 m) where the graph suggested that the coefficient remains approximately linear. The estimated slope from this extrapolation is indicated in the lowest row of this part of Table E-1. The corresponding intercept for this extrapolation is assumed to be zero. Note that the shaded values for slope and intercept estimates in this portion of the table are the ones used to estimate concentrations and concentration ratios in the lower portions of the table.

In the next lower portion of Table E-1, concentrations are estimated (relative to an arbitrary 1 g/sec release). Because we are only interested in looking at relative concentrations in this portion of the table, the actual release rate used to estimate airborne exposure concentrations is not important.

In the first column of this portion of the table, the distance downwind for which concentrations are estimated is presented. In this case, the distance is 3 m (10 ft). the next four columns of the table indicate the values extrapolated for σ_y (under “A” and “C” stability conditions) and σ_z (under “A” and “C” stability conditions), respectively. These are calculated as follows using the corresponding (shaded) slopes and intercepts indicated above:

$$\sigma_{ij} = \text{distance downwind*slope}_{ij} + \text{intercept}_{ij}.$$

Where:

the indices “I” and “j” refer to the vertical or horizontal coefficients and the “A” or “C” stability classes, respectively; and
all other parameters have been previously defined.

The sixth column of this portion of Table E-1 indicates the wind speed. Columns 7 through 10 indicate the estimated (relative) concentrations at ground level (for stability conditions “A” and “C”) and at 1.75 m (for the same stability conditions), respectively. Concentrations at ground level are calculated simply as:

$$1/(\pi\sigma_y{*}\sigma_z{*}U).$$

Where:

all parameters have been previously defined.

Concentrations at a height of 1.75 m (as described in Turner 1970) are calculated as:

$$1/(\pi\sigma_y{*}\sigma_z{*}U){*}\exp[-0.5(1.75/\sigma_z)^2].$$

Where:

all parameters have been previously defined.

As can be seen in the table, at a distance of as much as 3 m (10 ft) from a ground level source, concentrations at a height of 1.75 m are only about one fifth of what they are at ground level. As can be seen in the bottom-most portion of Table E-1 (which is identical to the section just described, except for the distance assumed), even at a distance of 5 m, concentrations at 1.75 m are less than one third of what they are at ground level.

The above concentration estimates and ratios assume that the receptor remains directly downwind of the source. Given that individuals are highly unlikely to constantly and continually walk, run, bicycle, or rototill directly into the wind (in fact, this is virtually impossible even if their might be a desire to do so), the direction of the trailing plume from these activities will vary radically over time (both absolutely and relative to the direction of travel). Thus, averaged over time and considering the above, concentrations even out to a distance of 5 m (or more) from the source are unlikely to completely mix to a height of 1.75 m.

Given the above, it appears that assuming a mixing height of 1.75 m (the height of a standing adult) and a width of 3 m represent reasonably conservative dimensions for a box within which concentrations can be considered to be well mixed for the purposes of estimating dispersion of emissions from these activities. Moreover, given that the participant remains much closer (laterally) to the source than 3 m, as previously indicated (Section 5.3.1), these models are much more appropriate for a receptor following constantly and continuously behind the individual generating the dust than for the generator of the dust (i.e. the participant) themselves.

Gardening, Children Playing in Soil, Handling ACM

The dimensions of the box assumed to estimate dispersion for these pathways were chosen conservatively to be approximately equal to the distance between an adolescent's hand and their nose when their arm is extended (0.5 m). It is highly unlikely that dust emitted from a ground level source will mix entirely within this small area before substantial numbers of the particles are swept away by the wind so that a substantial gradient is established between the source and the nose of the crouching participant.

Construction-related Activities

For operations that are potentially stationary (i.e. excavation and loading or dumping) a very small (and therefore highly conservative) "personal" box was constructed assuming a worker remains within a few meters directly downwind of the activity for an entire 8-hour shift (over the entire construction period). It was thus assumed that dispersion would only widen the plume from the activity to a width of 5 meters (15 ft). It was also assumed conservatively that dispersion would be limited to mixing within a height equal to the breathing zone of a typical worker (i.e. 1.75 m). This is much more highly conservative than the approach currently recommended by U.S.EPA (2002) in which it is assumed that construction activities contribute to contamination that is spread generally throughout the construction area. This latter model is employed here only for construction-related transport (for which it makes most sense) and for estimating exposure to neighboring residents from combined emissions during construction (see Table 16).

For operations involving mobile equipment (i.e. grading and transport), the near impossibility of having a pedestrian worker remain directly downwind within a few meters of moving equipment was recognized. Therefore, a larger box is assumed for these scenarios. Note, drivers of such equipment are typically exposed only minimally because they are constantly moving ahead of the dust cloud created by the equipment.

For mobile equipment, it is assumed conservatively that a worker might remain on average within 10 m to 20 m (30 to 60 ft) of such vehicles during an 8-hour shift and that most of the time, the worker would remain downwind. Consequently, a crosswind width for the source of 10 m is assumed. Given the larger size of the box and the larger distance, on average, over which dust must disperse before being inhaled by workers in these cases, a still conservative mixing height of 4 m (12 ft) is assumed for this box.

APPENDIX F: EVALUATION OF SOIL SAMPLES FROM THE NORTH RIDGE ESTATES SITE THAT WERE COLLECTED AND ANALYZED BY THE U.S.EPA AND AN EVALUATION OF THE RELATIVE ABUNDANCE OF CHRYSOTILE AND AMPHIBOLE ASBESTOS AT NORTH RIDGE

Results from the analysis of twelve samples collected and analyzed by the U.S.EPA at the North Ridge Estates site are presented in Table F-1. These samples were prepared and analyzed using the Modified Elutriator Method (Berman and Kolk 2000) in the same manner as the soil samples presented in the main study of this report. However, only the soil components of each sample of the set collected by U.S.EPA were analyzed. The ACM components were not analyzed.

In Table F-1, the first column indicates the sample identification number, the second column indicates the mass fraction of ACM observed in the sample, the third column indicates the analytical sensitivity achieved for analysis of each sample, and the fourth column indicates the type of asbestos detected (i.e. chrysotile or amphibole).

The fifth through ninth column of Table F-1 indicate, respectively, the number of asbestos structures observed that are: short protocol structures (5 µm < L < 10 µm), long protocol structures (L > 10 µm), 7402 structures (L > 5 µm), other ISO structures (primarily short, L < 5 µm), and total structures[2]. The 10th through 13th columns indicate, respectively, the estimated concentrations of total protocol structures, long protocol structures, 7402 structures, and other ISO structures. The last column of Table F-1 indicates the fraction of protocol structures that are longer than 10 µm.

The raw data from the analyses listed in Table F-1 were also provided by U.S.EPA (Wroble, private communication) so that the quality of these data could be evaluated. This also allowed an evaluation of the relative size distribution of the asbestos structures and the relative occurrence of amphibole asbestos observed among the samples analyzed.

Note that the results of the evaluation presented in this appendix are preliminary and a more detailed evaluation will be incorporated into the final risk assessment for this site.

Data Quality

Importantly, the data provided are "preliminary" meaning that the laboratory's internal QA/QC checks have not been completed at this point. In fact, some problems were noted. First, it was observed that the mass of the respirable dust deposited on some of the analytical filters was incorrect in that they were originally reported to be a factor of ten too small. It was also noted that the masses were determined using a mass

[2] In this table, "total structures" means all asbestos structures *of any length*. This contrasts with Tables 1 and 6, where "total structures" means the sum of protocol and 7402 structures, which are both longer than 5 µm. Thus, the quantities of total structures reported in Tables 1 and 6 cannot be compared to the quantities of total structures reported in Table F-1.

balance that does not satisfy the precision requirements for this method. Second, while the summary sheets did not list any detection of amphibole asbestos, on reviewing the raw count sheets, a small number of suspect amphibole structures were noted. Based on subsequent discussions with the laboratory (and additional evaluation by the laboratory), a subset of these structures were confirmed as amphibole asbestos (amosite). Despite these problems, the data are evaluated below (without adjustment) and their implications are included in the main body of this report.

Seven of the 12 samples reported by U.S.EPA exhibited four or more total structures and the counts of structures on the individual grid specimens of these samples were evaluated in the same manner described in Section 4.1.2 of the main body of this report to evaluate the uniformity of the deposits on each sample filter. Results indicate that, with the exception of Sample No. 508, filter deposits all appear to be adequately uniform to allow extrapolation of concentrations from the TEM analyses to the entire filter with confidence. The distribution observed on sample No. 508 is clearly not uniform. Nevertheless, analytical results from this sample were employed in the following evaluation without modification. Moreover, as there were no long structures or amphibole asbestos structures observed in this sample, it does not appear that problems with this sample adversely affect the conclusions of the following evaluation.

Because there are no blank or duplicate analyses reported among the U.S.EPA samples, it is not possible to evaluate either the potential for outside contamination or the overall performance of the analyses reported. At the same time, there is no specific evidence to suggest the kinds of problems that would normally be highlighted by these types of QC samples.

<u>Implications Concerning Structure Size and Field Consistency</u>

As can be from Table F-1, the twelve samples collected and analyzed by U.S.EPA exhibit a broad range of concentrations that vary by more than an order of magnitude (from $1.4x10^6$ to $4.7x10^7$ s/g_{PM10}) for short structures. There is also one sample in which no structures were detected. Moreover, a statistical analysis of these data (conducted in the manner described in Section 4.1.4) indicates that they are not mutually consistent.

The above-described results are not surprising given that the locations from which these samples were collected were selected purposely as a mix of high-traffic areas of residential yards and “hot spot” areas where high concentrations of ACM were observed either currently or prior to the last pickup of surface ACM (Mehnert, W. private communication, email message dated 6/10/04). Given the manner in which sample locations were selected, this set of samples should be considered to provide conservative (positively biased) measurements of asbestos concentrations that may be found in soils in residential yards at the North Ridge Estates site. However, the degree to which this set of samples is positively biased cannot be determined from available information.

It is also apparent from the data presented in Table F-1 that the vast majority of the asbestos structures observed are short (i.e. shorter than 5 μm). In fact, based on the raw data provided by U.S.EPA, 70 (or 80%) of the 86 structures detected among these samples are short. This is consistent with general observations concerning the size distributions of asbestos dusts in that the majority of structures in all such dusts are short (see, for example, Berman and Chatfield 1990).

Only a small number of the structures detected in the U.S.EPA samples are either protocol structures or 7402 structures, which are the structures that are evaluated to assess risk (see Section 5.4). These latter structures were observed in only two of the 12 samples analyzed and the observed concentrations of these latter structures range only up to $8x10^6$ s/g_{PM10} for protocol structures and up to $4x10^6$ s/g_{PM10} for 7402 structures.

Comparing the ranges of concentrations for protocol structures and 7402 structures observed in these samples with those reported for the composite samples in the main study (see Tables 1 and 6), it is apparent that they are consistent. Although the majority of samples in both sample sets exhibited no detectable protocol or 7402 structures, the upper 95% confidence limit concentration estimated for the samples from the main study ($9x10^6$ s/g_{PM10} - Table 16) is greater than the maximum observed concentration among the U.S.EPA samples for either protocol structures or 7402 structures. Thus, although the observed concentrations among the U.S.EPA samples are slightly greater than those observed in the main study (which is expected because the U.S.EPA sample set is positively biased), the two data sets are statistically consistent.

The relative consistency of the U.S.EPA samples and the composite samples from the main study does not appear to extend to the mass fractions of ACM observed among the two sets of samples. While the highest fraction of ACM in the composite samples from the main study is less than 0.9% (Table 6), ACM concentrations in the U.S.EPA samples range up to 4% by mass and one third of the samples contain more than 1% by mass. This is consistent with the fact that these samples were intentionally collected from “hot spot” areas (Mehnert, private communication, email message of 6/10/04).

Given the above, use of upper bound estimates of the asbestos concentrations observed among composite samples should be considered to be conservative for (and inclusive of) the results provided for the U.S.EPA samples. These, in turn, are expected to represent conservative estimates of the kinds of materials to which individuals may become exposed on their own properties (due to the locations from which they were collected). Moreover, because the concentrations from these samples that are used in the risk assessment are the maximum concentrations observed with contributions from the embedded ACM included, these estimates should be considered to be extremely conservative. This should remain true even though contributions from the ACM components were not reported for the U.S.EPA samples. This is because we are assuming that the ACM in the composite samples from the main study has completely degraded and released all of its asbestos, and this will certainly not occur for years to come (if ever).

It should also be noted that, although the composite samples collected in the main study do not exhibit ACM concentrations as high as those observed among the U.S.EPA samples, the complete data set from the main study (including the samples from hot spot areas) do appear to adequately bracket the U.S.EPA samples. With the hot spot samples included, the data set from the main study includes samples in which the fraction of ACM ranges up to 31% by mass. Moreover, as with the U.S.EPA samples, one third of the samples evaluated in the main study also exhibit ACM concentrations exceeding 1%. As indicated above, however, considering the full contributions from embedded ACM in the U.S.EPA samples (i.e. assuming that the ACM were to completely degrade) may not be necessary to assure that risk estimates are adequately conservative, at least for the purposes of this preliminary risk assessment. This consideration will be revisited in the final risk assessment for this site.

Implications Concerning the Presence of Amphibole Asbestos

As can be seen in Table F-1, two of the 12 samples collected by U.S.EPA (Nos. 512 and 518) exhibit detectable concentrations of amphibole (a single structure each). Based on the raw data, 2 of the 86 structures observed in this sample set (or 2%) are composed of amphibole asbestos. In comparison, 9 of 106 (or 8%) of the asbestos structures detected among the soil component samples of the main study are amphibole (all observed in a single hot spot sample). Thus, despite the fact that the U.S.EPA sample set was intentionally biased high, the data from the main study appear to adequately bracket the U.S.EPA results. Moreover, both of the amphibole structures detected in the U.S.EPA study are short (i.e. shorter than 5 µm so that they do not fall into the range of structures considered to be biologically active in this study). Because it is known that short structures universally represent the vast majority of any distribution of asbestos structures, the implication from this observation is that, if biologically active amphibole structures are indeed present in the general environment at the North Ridge Estates Site, they must be rare.

Given its particular importance for risk assessment, the prevalence of amphibole asbestos is evaluated below based on the incidence of amphibole asbestos observed in the U.S.EPA study and the main study (conducted to support this evaluation). Results from this evaluation are then supplemented with additional observations concerning the nature and distribution of amphibole-containing ACM observed in the field (see below and Section 5.5.2).

A summary comparison of the observed occurrence and concentrations of amphibole asbestos reported for the U.S.EPA data set and the data set from the main study in this document is presented in Table F-2. The comparison is designed to provide data useful for estimating overall exposure to amphibole asbestos at the North Ridge Estates Site.

In Table F-2, the first column indicates the specific study considered in each row (the U.S.EPA study, the main study, or the two studies combined). The second column indicates the specific sample set within each study considered. Thus, within the main study, the composite samples (representing average conditions over the site) and the hot spot samples (representing worst-case conditions) are each considered separately as well as combined. The subset of samples from the main study that were subjected to a full ISO count (including analysis for short structures) is also evaluated because this subset can be compared to (and combined with) the data for short structures from the U.S.EPA study. The third column of the table indicates the number of samples within each study/sample set considered.

The fourth and fifth columns of Table F-2 indicate, respectively, the estimated analytical sensitivity for each study/sample set considered and an indication whether each analytical sensitivity is derived based on individual samples or is pooled over the study/sample set considered.

The next four columns of the table indicate the maximum concentrations of amphibole asbestos observed, respectively, as total protocol structures, long protocol structures, 7402 structures, and short ISO structures. If no structures of a particular type were detected within the study/sample set considered, results for that structure type are reported as ND (non-detect). Because only samples in a subset from the main study were analyzed for short structures, some of the concentrations reported in this column are reported as NA (not analyzed).

For sample sets in which neither amphibole protocol structures nor amphibole 7402 structures were detected, the 10th and 11th columns of Table F-2 present upper confidence limit (UCL) concentration estimates that are appropriate for samples in which no structures are actually detected. Such concentrations are estimated to address the possibility that the small number of shorter amphibole structures that were detected (as previously noted) imply the presence of the longer protocol and/or 7402 structures (at concentrations too low to be observed among the samples analyzed).

UCL concentration estimates for samples in which no protocol or 7402 structures were detected are derived by considering that the probability of encountering a structure during an analysis is Poisson distributed. Based on a Poisson distribution, the upper 95% confidence limit on a count of zero is a count of three. Thus, the UCL's are set equal to the concentration equivalent to the detection of three structures and, correspondingly, are estimated simply as three times the analytical sensitivity for the study/sample set considered. Note that this is extremely conservative for the concentration of longer structures (i.e. protocol structures or 7402 structures), because such structures typically constitute no more than 10 to 20% of an asbestos distribution (Berman and Chatfield 1990) while the UCL's estimated in the manner described above are in fact higher than the concentrations of the shorter structures (< 5 μm) that were the only amphibole structures actually observed. Therefore, when applied in the risk assessment, the relative infrequency of detection of these structures is addressed by pooling the appropriate data sets to obtain more realistic estimates of analytical sensitivity.

The last four columns of Table F-2 provide measures of the frequency of occurrence for amphibole asbestos at the North Ridge Estates site, based on observations from each of the study/sample sets considered. The frequency of occurrence is estimated separately for short structures and biologically active structures in each of two ways. Column 12 presents the fraction of short asbestos structures observed in each study/sample set that are represented by amphibole asbestos and Column 13 indicates the fraction of the number of samples from each data set in which short amphibole structures were observed. Columns 14 and 15 of the table indicate the same information for biologically active structures.

Amphibole protocol or 7402 structures (i.e. biologically active structures) were only observed in a single sample in any of the studies (i.e. in one of 29 samples). Moreover, this sample (Hot Spot No. 6) was collected from a hole in a foundation, which is a location where the existence of steam-pipe insulation might not be unexpected. Correspondingly, a substantial number of amphibole asbestos structures were observed in this one sample.

In fact, steam-pipe insulation (as ACM) was observed in three limited areas of the North Ridge Estates site following the recent spring thaw (Wroble, private communication), although these areas were subsequently cleaned up. Moreover, insulation wrapped steam pipe is known to exist at depth in certain well-defined corridors of the site, based both on historical records and the results of a geophysical survey recently conducted (PBS 2004). Thus, the presence of this material is addressed explicitly in this risk assessment.

In addition, the detection of one short amphibole structure in each of two composite samples from the U.S.EPA study is conservatively considered to be evidence of a low level of general amphibole contamination that might be spread about the site. When combined with the four additional samples from the main study that were also analyzed for short structures, the occurrence of short amphibole structures is observed to be 2 in 16 samples or approximately 13%. As indicated above, although not detected directly, the presence of biologically active structures is inferred from the presence of the short structures and the concentrations are estimated in an extremely conservative fashion. Thus, the potential for general, low-level contamination with amphibole asbestos is also addressed in the risk assessment presented in this report.

TABLE F-1

SUMMARY OF ASBESTOS CONCENTRATION MEASUREMENTS IN SOIL SAMPLES COLLECTED BY U.S.EPA FROM THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

				Asbestos Structure Counts in Soil					Asbestos Concentrations in Soil				Fraction of Long Protocol in Soil
Soil Sample Number	**Fraction ACM (g/g)**	**Soil Analytical Sensitivity (s/g)**	**Asbestos Type**	**Short Protocol (Number)**	**Long Protocol (Number)**	**7402 (Number)**	**Other ISO (Number)**	**Total[a] (Number)**	**Total Protocol (s/g_{PM10})**	**Long Protocol (s/g_{PM10})**	**7402 (s/g_{PM10})**	**Other ISO (s/g_{PM10})**	**(%)**
500	0.0086	1.84E+06	Chrysotile	0	0	0	7	7				1.3E+07	
503	0.043	1.97E+06	Chrysotile	0	0	0	6	6				1.2E+07	
504	0.0050	1.97E+06	Chrysotile	1	3	2	24	28	7.9E+06	5.9E+06	3.9E+06	4.7E+07	75%
505	0	1.97E+06	Chrysotile	0	0	0	0	0					
506	0	1.73E+06	Chrysotile	0	0	0	1	1				1.7E+06	
508	0.034	1.38E+06	Chrysotile	0	0	0	11	11				1.5E+07	
509	0.023	1.02E+06	Chrysotile	0	0	0	4	4				4.1E+06	
512	0.014	1.26E+06	Chrysotile	0	0	0	9	9				1.1E+07	
		1.26E+06	Amphibole	0	0	0	1	1				1.3E+06	
		1.26E+06	Total	0	0	0	10	10				1.3E+07	
513	0	1.44E+06	Chrysotile	0	0	0	1	1				1.4E+06	
514	0.0012	1.84E+06	Chrysotile	0	0	0	3	3				5.5E+06	
518	0	1.71E+06	Chrysotile	0	0	0	0	0					
			Amphibole	0	0	0	1	1				1.7E+06	
			Total	0	0	0	1	1				1.7E+06	
519	0.0068	1.46E+06	Chrysotile	1	0	1	12	14	1.5E+06		1.5E+06	1.8E+07	0%
			TOTALS:	2	3	3	80	86					

Note: shading highlights the samples in which amphibole asbestos structures were detected among the samples analyzed.

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TABLE F-2:
OCCURRENCE OF AMPHIBOLE ASBESTOS AT THE NORTH RIDGE ESTATES SITE, KLAMATH FALLS, OREGON

Data Set	Sample Set	Number of Samples	Mean Analytical Sensitivity (s/g_{PM10})	Pooled?	Maximum Amphibole Concentrations: Protocol Structures (s/g_{PM10})	Maximum Amphibole Concentrations: Long Protocol Structures (%)	Maximum Amphibole Concentrations: 7402 Structures (s/g_{PM10})	Maximum Amphibole Concentrations: Short Structures (s/g_{PM10})	Maximum UCL Protocol Structures[b] (s/g_{PM10})	Maximum UCL 7402 Structures[b] (s/g_{PM10})	Short Structures: Fraction of Structures (%)	Short Structures: Fraction of Samples (%)	Biological Structures[a]: Fraction of Structures[c] (%)	Biological Structures[a]: Fraction of Samples (%)
U.S.EPA		12	1.6E+06	No	ND	ND	ND	2.E+06	<5.E+06	<5.E+06	2	17	0	0
		12	1.3E+05	Yes	ND	ND	ND	3.E+05	<4.E+05	<4.E+05				
Main Study														
	Composites[d]	10	2.0E+06	No	ND	ND	ND	NA	<6.E+06	<6.E+06			0	0
		10	2.0E+05	Yes	ND	ND	ND	NA	<6.E+05	<6.E+05				
	Hot Spots	7	2.0E+06	No	8.E+06	50	2.E+07	NA					8	14
	Total	17	2.0E+06	No	8.E+06	50	2.E+07	NA					**8**	6
	Full ISO Analyses	4		No				ND			0	0		
Combined														
	U.S.EPA & Composites	22	7.8E+04	Yes	ND	ND	ND	NA	<2.E+05	<2.E+05				
	U.S.EPA & Main Study	29	2.0E+06	No	8.E+06	50	2.E+07	NA					**8**	**3**
		29	6.1E+04	Yes	2.E+05	50	5.E+05	NA						
	U.S.EPA & Full ISO Analyses	16	1.3E+05	Yes				3.E+05			2	13		

Notes:

[a] In this context, biological structures is intended to mean the combination of protocol structures and 7402 structures.

[b] UCL concentration estimates for samples in which no protocol structures or 7402 structures were detected were derived based on the observation that the 95% upper confidence bound on a count of zero for Poisson distributed data is a count of three. Thus, the UCL concentration estimate for zero structures detected is equal to three times the analytical sensitivity (see text).

[c] These percentages exclude non-amphibole structures observed among the ACM components of each sample. Including such structures would substantially dilute these values.

[d] The number of structures reported for this sample set excludes the one "background" sample that was also analyzed along with the composite samples.

ND means "not detected."

NA mean "not analyzed."

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